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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte DAVID J. COOPERBERG, VAHID VAHEDI,
DOUGLAS RATTO, HARMEET SINGH, and NEIL BENJAMIN

Appeal No. 2008-6350
Application 10/024,208
Technology Center 1700

Decided:[1] February 27, 2009

Before EDWARD C. KIMLIN, CHARLES F. WARREN, and CATHERINE Q. TIMM, *Administrative Patent Judges*.

WARREN, *Administrative Patent Judge*.

DECISION ON APPEAL

Applicants appeal to the Board from the decision of the Primary Examiner finally rejecting claims 1 through 11, 13 through 15, and

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[1] The two month time period for filing an appeal or commencing a civil action specified in 37 C.F.R. § 1.304, begins to run from the "Decided" date shown on this page of the decision. The time period does not run from the Mail Date (paper delivery) or Notification Date (electronic delivery).

39 through 61 in the Office Action mailed September 7, 2006 (Office Action). 35 U.S.C. §§ 6 and 134(a) (2002); 37 C.F.R. § 41.31(a) (2006).

We affirm the decision of the Primary Examiner.

Claim 1 illustrates Appellants' invention of a plasma processing system, and is representative of the claims on appeal:

1. A plasma processing system comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is processed within the processing chamber;

a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;

a gas injector extending through the dielectric member, the gas injector comprising a body including an axial end surface exposed within the processing chamber, a side surface extending axially from the axial end surface, and a plurality of gas outlets including at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface, the off-axis outlets inject process gas at an acute angle relative to a plane parallel to an exposed surface of the substrate;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet;

flow controllers operable to supply process gas from the common gas supply at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

The Examiner relies upon the evidence in these references (Ans. [2] 3):

Goodyear	US 5,532,190	Jul. 2, 1996
Arami	US 5,958,140	Sep. 28, 1999
Ballance	US 6,090,210	Jul. 18, 2000
Powell	US 6,287,643 B1	Sep. 11, 2001
Murugesh	US 6,450,117 B1	Sep. 17, 2002
Chang	WO 99/57747 A1	Nov. 11, 1999
Ni[3]	WO 00/41212 A1	Jul. 13, 2000

Appellants request review of the grounds of rejection under 35 U.S.C. § 103(a) advanced on appeal: claims 1 through 11, 13, 14, and 39 through 61 over Ni in view of Chang or Murugesh and Arami or Goodyear or Ballance (Ans. 7); and claim 15 over Ni in view of Chang or Murugesh and Arami, or Goodyear, or Balance, as applied to claims 1 through 11, 13, 14, and 39 through 61, further in view of Powell.[4] App. Br. 10; Ans. 7 and 11.

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[2] We consider these documents: Appeal Brief filed June 24, 2007, as amended in the document filed October 9, 2007; Examiner's Answer mailed January 7, 2008; and Reply Brief filed March 6, 2008.

[3] Ni claims priority to, among other things, United States Application 09/223,273, filed December 30, 1998, which matured into US 6,230,651 B1 issued May 15, 2001, and is commonly assigned along with the instant Application to Lam Research Corporation.

[4] In the Decision entered April 6, 2006, in Appeal No. 2006-0290 (Decision) in this Application, we entered these grounds of rejection as new grounds of rejection. Decision 3 and 14-16. We further affirmed several of the Examiner's grounds of rejection under 35 U.S.C. § 103(a) and made another new ground of rejection of claims 51 through 55 under 35 U.S.C. § 103(a) over the combined teachings of Ni, Chang, Murugesh, Arami, Goodyear, Balance, and Hassan (US 4,270,999 issued June 2, 1981), and of certain claims under 35 U.S.C. § 112, second paragraph. Decision, e.g., 2-4. The affirmed grounds of rejection and the new ground of rejection under 35 U.S.C. § 112, second paragraph, were withdrawn by the Examiner in view of amendments to the claims in the Amendment filed June 6, 2006 (Amendment). Office Action 7-8. The Examiner also withdrew the

Appellants argue the claims in the first ground of rejection in the following groups: claim 1-6, 8-11, 13, 14, 39-43, 45-50, 56, and 58-61; claims 7, 44, and 57; and claims 51-55. App. Br. 13, 40, and 42. We decide this appeal based on claims 1, 7, 15, and 51 as representative of the grounds of rejection and Appellants' groupings of claims.[5] 37 C.F.R. § 41.37(c)(1)(vii) (2006).

The threshold issue in this appeal is whether Appellants have shown that the evidence in the combined teachings of Ni, Chang, Murugesh, Arami, Goodyear, and Balance with respect to claims 1, 7, and 51, and as further combined with Powell with respect to claim 15 would not have disclosed a plasma processing system as claimed to one of ordinary skill in this art, and if not, the issue with respect to the grounds of rejection is whether Appellants have shown that the evidence of record, including the Cooperberg Declaration, weighs in favor of nonobviousness.

In order to consider the issues raised in this appeal, we first interpret independent claims 1 and 7 and claims 15 and 51, dependent on claim 1, by giving the terms thereof the broadest reasonable interpretation in their

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rejection that included Hassan and added claims 51 through 55 to the first ground of rejection above on the basis Ni has similar disclosure to Hassan. Office Action 8; *see* Dec. 3 and 16. Appellants further changed the record from the prior appeal by submitting Appellant Cooperberg's Declaration under 37 C.F.R. § 1.132 (Cooperberg Declaration) with the Amendment. App. Br., Evidence Appendix.

[5] Appellants' contentions with respect to claims 9, 41, and 42 merely recite the limitations of these claims, which does not constitute argument for separate patentability. App. Br. 33-34; 37 C.F.R. § 41.37(c)(1)(vii) (2006) ("A statement which merely points out what a claim recites will not be considered an argument for separate patentability.").

ordinary usage in context as they would be understood by one of ordinary skill in the art in light of the written description in the Specification unless another meaning is intended by Appellants as established therein, and without reading into the claims any disclosed limitation or particular embodiment. *See, e.g., In re Icon Health and Fitness, Inc.*, 496 F.3d 1374, 1379 (Fed. Cir. 2007); *In re Am. Acad. of Sci. Tech. Ctr.*, 367 F.3d 1359, 1364 (Fed. Cir. 2004), and cases cited therein; *In re Morris*, 127 F.3d 1048, 1054-55 (Fed. Cir. 1997).

We determine claim 1 specifies in pertinent part, as illustrated by the embodiments depicted in Specification Figures 1 and 2a-c, a plasma processing system comprising at least the specified apparatus components including, among other things, plasma processing chamber 10 having dielectric member 20 that faces substrate support 12 and is between RF (radio frequency) antenna 18 and impedance matching circuitry 19 that inductively couples RF energy into chamber 10. Gas injector 22 has a side surface extending axially from the axial end surface, and extends through dielectric member 20 such that the axial end surface is exposed in chamber 10. *See* Spec. 10-11. Gas injector 22 has an on-axis injection outlet 24 in the axial end surface and two or more spaced-apart off-axis outlets 26 in the side surface, wherein off-axis outlets 26 inject gas at an acute angle relative to a plane parallel to an exposed surface of a substrate on substrate support 12. *See* Spec. 12-13. Claim 15 further limits claim 1 in specifying that gas injector 22 has an electrically conducting shield which minimizes plasma ignition within the gas outlets. *See* Spec. 13 and Fig. 2c.

We further determine claim 1 specifies common gas supply 23 is in fluid communication with first gas line having flow controller 36a that is in fluid communication with only on-axis injection outlet 24, and with second gas line having flow controller 36b that is in fluid communication with only off-axis outlets 26, wherein the respective flow controllers independently vary the gas flow in the lines. *See* Spec. 11-13.

We interpret the term "common gas supply" in light of the Specification to encompass any gas supply structure capable of supplying the same gas to both gas lines. Indeed, there is no claim language or disclosure in the Specification which limits the common gas supply to a single gas line that is in fluid communication with the gas lines to the gas outlets as illustrated in Figures 1 and 2a-c. *See* Spec. 11-12. The term "common gas supply" does not encompass a particular gas such as a "process" gas as stated in claim 1, "a gas mixture" as stated in claim 51, or "the same gas composition" as Appellants contend, because such recitations do not structurally limit any apparatus component of the claimed system. *See* App. Br., e.g., 16; *see also* Reply Br. 7-8. In this respect, we point out that a "gas" on which an apparatus component can perform work does not confer a structural limitation on the claimed system. *See, e.g., In re Otto*, 312 F.2d 937, 939-40 (CCPA 1963); *In re Rishoi*, 197 F.2d 342, 344-45 (CCPA 1952) ("[T]here is no patentable combination between a device and the material upon which it works."); *In re Young*, 75 F.2d 996 (CCPA 1935); *In re Smith*, 36 F.2d 302, 303 (CCPA 1929)("It will be borne in mind that it has been long established that a person may not patent a combination of

device and material upon which the device works, nor limit other persons from the use of similar material by claiming a device patent.").

We determine claim 7 encompasses substantially the same plasma processing systems as claim 1. In this respect, claim 7 specifies, among other things, that the on-axis outlet of the gas injector receives process gas from a center passage in the injector which is in fluid communication with a first gas line of a common gas supply, and the off-axis outlets receive process gas from an annular passage surrounding a central passage that is in fluid communication with a second gas line of that gas supply. Such an injector falls within the claim language of claim 1. Claim 7 specifies that the side surface of injector 22 must be "conical" to any extent. We agree with Appellants that this term has its common, ordinary meaning as reflected in the conical shape of injector 22 extending below dielectric member 20 illustrated in Figures 2a-c. App. Br. 41.[6]

The transition term "comprising" opens claims 1 and 7 to encompass processing systems containing any manner of additional structural components. *See, e.g., KCJ Corp. v. Kinetic Concepts, Inc.*, 223 F.3d 1351, 1356 (Fed. Cir. 2000); *Vehicular Techs. Corp. v. Titan Wheel Int'l, Inc.*, 212 F.3d 1377, 1383 (Fed. Cir. 2000); *In re Baxter*, 656 F.2d 679, 686 (CCPA 1981).

While we refer to embodiments illustrated in Specification Figures 1 and 2a-c in interpreting claims 1, 7, 15, and 51, we find no basis in the language of these claims or in the disclosure in the Specification on which

[6] *See, e.g.*, **conical**, *The American Heritage Dictionary of The English Language* 389 (4th ed., Boston, Houghton Mifflin Company, 2000).

to limit the claims to these embodiments. *See, e.g.*, *In re Zletz*, 893 F.2d 319, 321-22 (Fed. Cir. 1989).

We find Ni would have disclosed to one of ordinary skill in this art, as illustrated by embodiments depicted in Figures 1 and 3a-c, a plasma processing system including plasma processing chamber 10 having dielectric member 20 that faces substrate support 12, and is between RF antenna 18 and impedance matching circuitry 19 that inductively couples RF energy into chamber 10. Ni 9-10 and 11; *see also* 5-7 and 8. Gas injector 22 extends below the lower surface of dielectric member 20 at least to the extent that a plurality of gas outlets in the axial end surface are within processing chamber 10, and is connected to gas supply 23. Ni 9-10 and 11; *see also* 8. In "Figure 3a, the gas injector 22 includes a cylindrical body 40[,] . . . a central bore 44 extending through the upper axial end, and a plurality of gas outlets 46 extending between the bore and the exterior surface of the lower axial end . . . ." Ni 11:7-10. The inductively coupled RF energy energizes gas injected into chamber 10 into a plasma state. Ni, e.g., 5-7 and 10.

Ni discloses:

> The . . . gas injector can inject the process gas toward a primary plasma generation zone in the chamber. The gas outlets can be located in an axial end surface of the gas injector. For instance, the gas outlets can include a center gas outlet extending in an axial direction perpendicular to the exposed surface of the substrate and a plurality of angled gas outlets extending at an acute angle to the axial direction. . . . The gas outlets can have various configurations and/or spatial arrangements. For example, the gas injector can include a closed distal end and the gas outlets can be oriented to inject

process gas at an acute relative to a plane parallel to an exposed surface of the substrate.

Ni 5:26 to 6:12.

Ni discloses:

The number of gas outlets and/or angle of injection of gas flowing out of the gas outlets can be selected to provide desired gas distribution in a particular substrate processing regime. For instance, the number, size, angle of injection and/or location of the outlets within the chamber can be adapted to a particular antenna design used to inductively couple RF energy into the chamber, the gap between the upper wall and the exposed surface of the substrate, and etch process to be performed on the substrate.

Ni 9:1-7.

Ni discloses:

According to a preferred embodiment, the gas injector is a cylindrical member having . . . either 8 or 9 gas outlets in one end thereof. The 9 gas outlet arrangement is useful for a polysilicon etching process and the 8 gas outlet arrangement is useful for an aluminum etching process. In the 9 hole arrangement, one hole is provided in the center of the axial end of the gas injector and 8 holes . . . located adjacent the outer periphery of the axial end. In the 8 hole arrangement, the center hole is omitted. In either case, the 8 holes can extend axially or they can be at an angle to the central axis of the bore extending part way through the gas injector.

Ni 13:9-19.

Ni discloses:

The gas injector advantageously allows an operator to modify a process supply arrangement for a plasma etch reactor to optimize gas distribution in the reactor. For example, in plasma etching aluminum, it is desirable to distribute the process gas into the plasma rather than direct the process gas directly towards the substrate being etched. In plasma etching

> polysilicon, it is desirable to distribute the process gas into the plasma and direct the process directly towards the substrate being etched. Further optimization may involve selecting a gas injector which extends a desired distance below the inner surface of the window and/or includes a particular gas outlet arrangement. That is, depending on the etching process, the number of gas outlets, the location of the gas outlets such as on the axial end and/or along the sides of the gas injector as well as the angle(s) of injection of the gas outlets can be selected to provide optimum etching results. For example, the angle of injection is preferably larger for larger size substrates.

Ni 14:3-15.

Ni discloses:

> The gas injector can be used to plasma etch aluminum by injecting the process gas into the interior of the chamber such that the gas is not injected directly towards the substrate being processed. In a preferred embodiment, the gas injector does not include a central gas outlet in the axial end thereof. Instead, 4 or 8 gas outlets located around the periphery of the axial end are used to inject gas. . . .
>
> The gas injector can also be used to plasma etch polysilicon by injecting the process gas into the interior of the chamber such that the gas is injected directly towards the substrate being processed. In a preferred embodiment, the gas injector includes a central gas outlet in the axial end thereof and 4 to 8 gas outlets located around the periphery of the axial end. . . .

Ni 14:16 to 15:4.

Ni discloses "[t]he gas outlets can be orientated to inject the gas in any direction, including directly at the substrate, at an acute angle with respect to the substrate, parallel to the substrate or back toward the upper plasma boundary surface (at an oblique angle with respect to the longitudinal axis of the nozzle), or combinations thereof." Ni 20: 6-10.

Ni discloses the injector should have no sharp corners at the distal end in order to reduce local electric field enhancement near the tip. Ni 20:15-16; *see also* 17:4-21.

We find one of ordinary skill in this art would have found from Figures 1 and 3a-c and the disclosure of Ni, particularly the description of Figure 3a, that illustrated injectors 22 have off-axis outlets adjacent the periphery of the axial end surface that inject gas at an acute angle relative to a plane paralleled to an exposed surface of the substrate, and do not have a central on-axis gas outlet.

We find Chang would have disclosed to one of ordinary skill in this art, as illustrated by embodiments depicted in Figures 1 and 7, a plasma processing system for film deposition including gas delivery system 46 which includes a gas injector extending through dielectric member 50 into process chamber 38, and RF system 42 which couples RF energy into chamber 38. Chang 6-9 and 18-19. The injector includes a central passage connecting gas source 100a via flow controller 120a and gas delivery lines 92 with top nozzle 96 which is an on-axis outlet in the distal end of the injector. The injector further has an annular passage surrounding the central passage, which annular passage connects gas sources 100b and 100d via flow controllers 120b and 120c and gas delivery lines 92 to top vent 98 that "is an annular opening," that is, an outlet, "around the top nozzle 96." Chang 9 and 18. We find one of ordinary skill in this art would have found from FIGS. 1 and 7 that only the structure forming the interior surface of top vent 98 and the exterior surface of nozzle 96 and acting to shape the gas

flowing through top vent 98, extends below the lower surface of dielectric member 50 into plasma processing region 52.

Chang discloses "[t]he top nozzle 96 and top vent 98 allow independent control of top and side flows of the gases, which improves film uniformity and allows fine adjustment of the film's deposition and doping parameters." Chang 9:25-28.

We find Murugesh would have disclosed to one of ordinary skill in this art, as illustrated by embodiments depicted in Figures 1A and 3, a plasma processing system for film deposition including plasma processing chamber 30 wherein gases are provided through first gas distributor 65 and second gas distributor 215. The two gas distributors can be in different locations in chamber 30 as shown in Figure 1A or combined into a single injector in ceiling 55 of chamber 30 as shown in Figure 3. Murugesh, e.g., col. 3, ll. 40-55, col. 5, l. 41 to col. 7, l. 12, and col. 7, l. 65, to col. 8, l. 7. In Figure 1A, second gas distributor 215 is located in ceiling 55 of chamber 30, and has a central passage to outlets 247b and an annular passage to outlets 247a, both of which are in fluid communication with a common gas or plasma supply. Murugesh, e.g., col. 5, l. 41 to col. 7, l. 32. In Figure 3, first gas distributor 65 and second gas distributor 215 "are combined in a single structure," wherein a gas supply line with flow controller 80 provides a gas through a central passage to "first gas outlets 85" and another gas supply line 170 with flow controller 120 provides another gas through an annular passage to "second gas outlets 247." Murugesh col. 7, l. 65, to col. 8, l. 7. Plasma generator 110 inductively couples RF energy into chamber 30 using inductor antenna 115 on dielectric ceiling 55. Murugesh, e.g.,

col. 4, ll. 1-14.

We find Arami would have disclosed to one of ordinary skill in this art, as illustrated by embodiments depicted in Figures 2 and 5, CVD processing system 20 which includes processing chamber 21 having gas reaction region 49 and shower head injector section 35. Shower head injector section 35 has three concentrically, arranged gas chambers 37A, 37B, 37C each of which is in fluid communication with a gas supply pipe 38, 39, 40, respectively. Each supply pipe has a mass flow controller 44A, 44B, 44C, respectively, which in turn is connected to a gas supply source 41, 42, 43, respectively. The mass flow controllers "can individually manage the gas supply amounts to the corresponding gas supply pipes." Arami, e.g., col. 3, ll. 23-35, col. 4, ll. 31-57, and col. 4, l. 66 to col. 5, l. 26; *see also, e.g.*, col. 1, ll. 9-39.

Arami discloses

> A processing gas can be independently supplied to the respective gas chambers 37A to 37C . . . independently controlled by the mass-flow controllers . . . [such that] gas reaction region 49 . . . can be divided into three zones, and the processing gas can be supplied while changing the supply amounts for the respective zones. As a result, the gas supply amount per unit area to the wafer W can be arbitrarily changed for each zone, unlike a shower head section with a conventional structure in which the interior is not divided. Accordingly, various types of films can be formed in various processes with high in-plane uniformity.

Arami, col. 10. ll. 32-44.

We find that Goodyear would have evinced to one of ordinary skill in the art that in the plasma processing system disclosed in

> JP-A-56-873328, the gas mixture is supplied to the perforated electrode by the first supply line feeding a central area of the perforated electrode and by the second supply line feeding a peripheral area of the perforated electrode. The gas flow over the substrate is radially outwards from the central area. In this known apparatus and method the same gas mixture is fed to both the peripheral and center areas, but at different rates which are controlled by a first mass flow meter on the first supply line and a second mass flow meter on the second supply line. This permits a reduction of non-uniformities in the plasma between the central area and the peripheral area.

Goodyear, col. 1, ll. 39-50; *see also* col. 1, ll. 22-38.

We find Goodyear would have disclosed to one of ordinary skill in the art, as illustrated by embodiments depicted in Figure 1, a perforated gas-feeding showerhead electrode 12 for the chamber of a plasma processing system that employs RF energy. Goodyear, e.g., col. 2, ll. 11-53, and col. 3, l. 64 to col. 4, l. 19. Showerhead electrode 12 has first supply line 21 that feeds central area 12a, and second supply line 22 that feeds annular peripheral area 12b. Goodyear, e.g., col. 2, ll. 11-53, col. 4, ll. 20-36, and Fig. 1. Goodyear discloses the problem that where an identical gas composition is fed via the lines 21 and 22, one of the gases in the composition can be depleted at a faster rate. Goodyear solves the problem by using valves and flow meters 26a, 23a, 24a, 55, 56 and 26b, 23b, 24b, 55, 56 in supply lines 21, 22, respectively, which provides the capability to independently adjust the amount of each of the ingredient gasses in the gas supplied to each of areas 12a, 12b of perforated electrode 12 so that "the

plasma treatment is carried out more uniformly over the area of the . . . electrode." Goodyear, e.g., col. 2, ll. 11-67, and col. 4, l. 43 to col. 5, l. 59.

We find Ballance would have disclosed to one of ordinary skill in this art, as illustrated by embodiments depicted in Figures 5 and 8, a multi-zone gas flow control showerhead 100 with multiple gas injection holes, for a process chamber of a rapid thermal processing system for film deposition. Balance, e.g., col. 1, ll. 7-26, col. 2, l. 49 to col. 3, l. 11, col. 3, l. 38 to col. 4, l. 10, col. 5, l. 11 to col. 7, l. 10, and Figs. 1 and 4. In Figure 5, showerhead 100 is in fluid communication with a gas source which delivers gas to inner hole array 102 through inlet port 103 and a second gas source delivers gas to outer hole array 104 through inlet port 105, that makes it "possible to independently control the flow rates through the two gas distribution hole arrays and thereby have greater control over the contour of the gas flow distribution over the surface of the substrate." Balance col. 7, ll. 10-24.

Ballance discloses in Figure 8, showerhead 300 having a common gas supply line from gas supply 314 in fluid communication with gas line 312 having flow controller 318 for central circular chamber 308 and with gas line 310 having flow controller 316 for annular outer chamber 306. The gas supply 314 is "pressurized gas . . . (or gases)" and flow controllers 316, 318 are "programmably controlled." Balance, col. 8, ll. 34-53. "[W]ith a dual zone showerhead (or a multi-zone showerhead) it will be possible to reduce the pressure of the gas supplied to the center holes as compared to the outer holes." Balance, col. 3, ll. 10-15.

We find Powell would have disclosed to one of ordinary skill in this art that an electrically conducting shield on the side surfaces of an injector minimizes plasma ignition. Powell, e.g. col. 9, ll. 33-50, and Fig. 5; *see also* col. 7, l. 57 to col. 9, l. 20.

We determine the Examiner's findings of fact and conclusions of prima facie obviousness of claims 1, 7, 15, and 51 are adequately supported by the evidence in the combined teachings of Ni, Chang, Murugesh, Arami, Goodyear, and Balance, with respect to claims 1, 7, and 51, and as further combined with Powell, with respect to claim 15. Ans. 7-12.

Thus, we reconsidered the record as a whole in light of Appellants' contentions, including the evidence in the Cooperberg Declaration, and are of the opinion that Appellants have not successfully shown that the combined teachings of Ni, Chang, Murugesh, Arami, Goodyear, and Balance and as further combined with Powell would not have disclosed a plasma processing system as claimed to one of ordinary skill in this art.

Considering first, the teachings of the references, we cannot subscribe to Appellants' apparent contention that the teachings of Ni are limited to the injector embodiments depicted in Figures 1 and 3a-c in view of the teachings of Ni as a whole. App. Br., e.g., 17, 21, and 24; Reply Br., e.g., 3 and 4. *See, e.g., In re Lamberti,* 545 F.2d 747, 750 (CCPA 1976) ("[T]he fact that a specific [embodiment] is taught to be preferred is not controlling, since all disclosures of the prior art, including unpreferred embodiments, must be considered."). We determine one of ordinary skill in this art would have reasonably inferred from the description of Figure 3a and other disclosure in Ni, that injectors 22 illustrated in Figures 1 and 3a-c have

off-axis outlets adjacent the periphery of the axial end surface, and do not have a central on-axis gas outlet. *See above* pp. 8-11. However, Ni teaches that suitable injectors can contain an on-axis gas outlet in the axial end surface and contain off-axis gas outlets in the side surfaces, and the off-axis gas outlets can inject gas at an acute angle relative to a plane parallel to an exposed surface of a substrate, as claimed in claim 1. *See above* pp. 8-10. Indeed, there is no disclosure in Ni limiting the off-axis outlets to the axial end surface of the injector as Ni discloses that the off-axis outlets can be on the sided of the injector. *See above* pp. 9-10 (Ni 14:3-15). In this respect, we further determine Ni's disclosure that the distal end of the injector should have no sharp corners would have led this person to use a conical shaped injector in place of the cylindrical shaped injector having an angle formed between the sides and the distal end, thus meeting this limitation of claim 7 as we interpreted this claim above. *See above* pp. 8 and 11.

We agree with Appellants that in Ni's injector, gas is supplied to all outlets from a central bore, that is, central passage, as illustrated in Figures 3a-c, which is in fluid communication via a single line to a gas supply, as illustrated in Figure 1. *See above* p. 8; App. Br., e.g., 17. We disagree with Appellants' contentions that one of ordinary skill in this art routinely following the combined teachings of Ni, Chang, Murugesh, Arami, Goodyear, and Balance would not have modified Ni's injector by separating the gas supply to the gas outlets such that the on-axis outlet receives process gas from a center passage in the injector which is in fluid communication with a first gas line of a common gas supply; the off-axis outlets receive process gas from an annular passage surrounding a central passage that is in

fluid communication with a second gas line of that gas supply; and the gas lines have flow controllers to independently vary the flow rate through the gas lines, as claimed in claims 1 and 7.

Appellants do not dispute that each of Chang and Murugesh discloses cylindrical injectors in which a center passage connects a gas supply with an on-axis outlet and an annular passage connects a different gas supply with off-axis outlets, and that the flow of gas in each of the lines supplying the different gases to the respective outlets is independently controlled by flow controllers. *See above* 11-13; Ans. 8-9. Indeed, Appellants merely point out that these references supply different gas to each of the passages, and thus not the same gas from a common gas supply. App. Br. 18-19 and 25-27; Reply Br. 4-5.

Appellants also do not dispute that each of Arami, Goodyear, and Balance disclose a shower head injector separated into two or three chambers, each of which is in fluid communication with a gas line having a flow controller that regulates the gas flow for that line, or that each of Goodyear and Balance discloses that the gas lines for the chambers of the shower head injectors are connected to a gas source that supplies the same gas. *See above* pp. 13-15; App. Br., e.g., 19-20, 29-30, and 32. Contrary to Appellants' contentions, we agree with the Examiner that Arami would have disclosed to one of ordinary skill in this art that the gas lines for the chambers of the shower head injector are connected to gas sources that can supply the same gas using the flow controllers. *See above* p. 13; Ans. 9; App. Br. 20 and 32-33.

Turning now to Appellants' contentions that a prima facie case has not been established by the evidence in the applied references, we agree with Appellants that one of ordinary skill in this art would find in Ni the teachings that the outlets of the injector are arranged, as stated by Ni, "to provide desired gas distribution in a particular substrate processing regime." *See above* p. 9; App. Br., e.g., 14-15 and 22-24, citing Cooperberg Declaration ¶¶ 3, 5, and 6. However, contrary to Appellants' contentions, we are of the opinion that Ni's disclosure of different arrangements of on- and off-axis gas outlets for aluminum (all off-axis outlets) and polysilicon (one on-axis outlet and remainder off-axis outlets) etch processes in order to provide the desired gas distribution for the processes, would have reasonably suggested to one of ordinary skill in this art that the capability to close off the on-axis gas outlet in the axial end of an injector would result in an injector that can provide desired gas distribution for both aluminum and polysilicon etch processes. *See above* pp. 9-10.

Indeed, this person would have been armed with the knowledge in the art that an injector can be divided into passages or chambers in order to regulate gas flow and the composition of that gas in providing the desired gas to outlets of the injector as evidenced by Chang, Murugesh, Arami, Goodyear, and Balance. *See above* pp. 11-15. Thus, this person would have readily recognized that a change in the structure of Ni's injector using separate passages or chambers to control the flow of gas to different gas outlets, as known in the art, would facilitate separate control of the on- and off-axis gas outlets in Ni's injector, thereby permitting the modified injector to be used in different etch processes. *See, e.g., KSR Int'l Co. v. Teleflex*

Inc., 127 S.Ct. 1727, 1740 (2007) ("[I]f a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill."); *In re Keller*, 642 F.2d 413, 425 (CCPA 1981)(("[T]he test [for obviousness] is what the combined teachings of the references would have suggested to those of ordinary skill in the art."); *In re Sovish*, 769 F.2d 738, 743 (Fed. Cir. 1985) (skill is presumed on the part of one of ordinary skill in the art); *see also In re O'Farrell*, 853 F.2d 894, 903-04 (Fed. Cir. 1988) ("For obviousness under § 103, all that is required is a reasonable expectation of success." (citations omitted)).

In this respect, there is little support in the record for Appellants' contention that the problem addressed by the claimed injector is one of providing an "etch uniformity in different etch steps of a multi-step etch process" which would not have been recognized by one of ordinary skill in this art. App. Br., e.g., 13-16, 21-24, and 38-39, citing Cooperberg Declaration ¶¶ 3-6. Indeed, one of ordinary skill in this art would have required only the simple observation of the difference between Ni's injectors for etching aluminum and polysilicon to recognize that the problem with using the same injector in these different etching processes is the presence and absence of an on-axis gas outlet in the axial end. Thus, this person would have reasonably concluded that control of the on-axis gas outlet would permit use of the same injector in both etching processes. *See, e.g., In re Ludwig*, 353 F.2d 241, 242-43 (CCPA 1965) (if only simple observation

is required to ascertain a problem, the recognition of such problem is well within the ordinary skill in the art); *In re Goodman*, 339 F.2d 228, 232-33 (CCPA 1964) ("The problem solved by appellants, if not specifically pointed out by the prior art, was at least an obvious one. The means of solving the problem were clearly suggested by the prior art.").

We further cannot agree with Appellants that the teachings of Ni would have led one of ordinary skill in this art away from considering the showerhead injector art set forth in Arami, Goodyear, and Balance, or that the teachings of Goodyear would have led this person away from using a common gas supply. App. Br. 27-28 and 30-32; Reply Br. 6-8. "A reference may be said to teach away when a person of ordinary skill, upon reading the reference would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant." *In re Gurley*, 27 F.3d 551, 552-53 (Fed. Cir. 1994). In other words, a prior art disclosure does not teach away if the "disclosure does not criticize, discredit, or otherwise discourage the solution claimed." *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004).

In this respect, we find no evidence in Ni that the disclosure "instead of using a gas ring or showerhead to supply process gas into the chamber, the gas injector is mounted in an opening through the dielectric window," establishes one of ordinary skill in this art would have been discouraged from considering showerhead injectors having a plurality of chambers for independent control of gas flow in modifying Ni's injector, as Appellants contend. App. Br. 27-28, citing Ni 9:13-15. Indeed, the statement is made with respect to the modification of a particular plasma etch reactor made by

LAM Research Corporation to demonstrate Ni's injector, and thus does not constitute a preference for any particular injector. Ni 9:9-13.

We are also unpersuaded of a "teaching away" from a common gas supply by the disclosure of a problem with depletion of one of the reaction gases delivered through a showerhead injector. App. Br. 30-32, citing Goodyear, col. 4, ll. 48-56, and Cooperberg Declaration ¶ 12; Reply Br. 6-8; *see above* pp. 13-14. Goodyear's disclosed solution to this problem is adjustment of the gases supplied to the injector, and thus a process adjustment. *See above* p. 14. Indeed, we find that the disclosed solution is a gas supply structure, the disclosure of which would have led one of ordinary skill in this art to the reasonable inference that the process gas supplied to each of areas 12a, 12b of the showerhead injector can be of the same composition. *Id.*

In this respect, Appellants acknowledge that Goodyear evinces that a similar plasma processing system in which the two chambers of the showerhead injector are in fluid communication with the same gas supply was known in the art. App. Br. 19, citing Goodyear, col. 1, ll. 20-53; *see above* pp. 13-14; *cf., e.g., In re Hedges*, 783 F.2d 1038, 1039-40 (Fed. Cir. 1986).[7] Arami and Balance also disclosed such compartmentalized

[7] "In Hedges' case, the Solicitor referred to new portions of the references cited by Hedges during examination for further support of the same rejection that had been upheld by the Board. Hedges had relied on these references before the Board, as he does before us, for his argument that viewed as a whole the body of the prior art teaches away from conducting this reaction at high temperatures. The Solicitor should not be constrained from pointing to other portions of these same references in contravention of Hedges' position." *Hedges*, 783 F.2d at 1039-40.

showerhead injectors as we have discussed above. *See above* pp. 13 and 15. Thus, one of ordinary skill in this art, armed with the knowledge in the art that an injector can be divided into chambers in order to regulate gas flow and composition as evidenced by Chang, Murugesh, Arami, Goodyear, and Balance, would not have been led away from using the concept of a showerhead injector having a plurality of chambers for independent control of gas flow taught by Arami, Goodyear, and Balance by Goodyear's disclosure cited by Appellants. *See, e.g., Gurley*, 27 F.3d at 553 ("We share Gurley's view that a person seeking to improve the art of flexible circuit boards, on learning from Yamaguchi that epoxy was inferior to polyester-imide resins, might well be led to search beyond epoxy for improved products. However, Yamaguchi also teaches that epoxy is usable and has been used for Gurley's purpose.").

Appellants also contend that one of ordinary skill in the art would not have looked to showerhead injector design with respect to construction and performance when used in RF capacitively-coupled plasma reactors in modifying Ni's injector for used in an RF inductively-coupled plasma processing system. App. Br. 28-30 and 33. In this respect, Appellants point to, among other things, the number and position of the gas outlets in the injector. App. Br. 28. In this respect, Appellants further point out that Declarant Cooperberg's opinion that one of ordinary skill in the art "would not have selected references in the showerhead electrode art to modify the Ni gas injector, which is used in an ICP system," "is based on well-known differences in the art and reflects the knowledge in the art." App. Br. 28-29, *citing* Cooperberg Declaration ¶ 13.

We find that Declarant Cooperberg states, among other things, that "[r]egarding gas flow, because a showerhead includes many holes, the gas exit velocity is normally sufficiently low," and that "[t]he higher flow rate from a smaller number of holes for the claimed gas injector allows for more controlled directivity from the injector." Cooperberg Declaration ¶ 13.

We disagree with Appellants' position. We determine that one of ordinary skill in this art would have had knowledge that the flow of gas to outlets of an injector can be regulated by dividing the injector into chambers in order to regulate gas flow and composition as evidenced by Chang, Murugesh, Arami, Goodyear, and Balance. Each of these references would have disclosed that the gas flow to the outlets of an injector is regulated by compartmentalizing the injector into passages or chambers, each in communication with a gas source via a gas line having a flow controller. *See above* pp. 11-15. Indeed, the disclosure of Chang and Murugesh in this respect is essentially the same as that of Arami, Goodyear, and Balance. Thus, the structure of an injector considered by one of ordinary skill, in addressing the problem of control of gas to the outlets of an injector, would have been determined by the injector structure and not by the type of processing system in which the injector is used or the arrangement of the outlets. The testimonial evidence we find in ¶ 13 of the Cooperberg Declaration directed to gas flow rate is with respect to the injection of gas from a gas outlet of the injector and not with control of the flow of gas to that gas outlet with respect to gas distribution to the outlets of an injector, and thus, is not directed to the approach of one of ordinary skill in this art to that problem.

Appellants' sole contention with respect to claim 51 is that the combined teachings of the applied references do not teach the claim limitation "the common gas supply is a gas mixture." App. Br. 42. We determined above that this claim language does not express a structural limitation of the claimed plasma processing system. *See above* pp. 6-7. In any event, Appellants do not point out why the gas supply systems of the applied references are incapable of supplying a gas mixture.

Appellants merely contend with respect to claim 15 that Powell "fails to cure the . . . deficiencies of Ni" or otherwise disclose limitations specified in claim 1. App. Br. 42-43. This argument does not address the manner in which Powell was combined with the other references.

Appellants have not successfully shown that the combined teaching of the applied references would not have disclosed a plasma processing system as claimed to one of ordinary skill in this art, and thus, we now consider the evidence in the Specification and the Cooperberg Declaration as argued in the Briefs.

We find Declarant Cooperberg states "Examples at [Specification] pages 19-21 . . . demonstrate superior process results . . . can be provided by the claimed plasma processing system." Decl. ¶ 8. The plasma processing system used in the Examples is generally described. *Id.* Examples 1 through 5 are reported at Specification pages 19-21. Declarant Cooperberg sets forth a table showing test reports for Examples 1 to 3. Decl. ¶ 8. The processes in Examples 1-3 are "polysilicon etch," "silicon etch," and "polysilicon gate etch," respectively. *Id.* Declarant Cooperberg provides no results for or otherwise describes Specification Examples 4 and 5. *Id.*

Declarant Cooperberg states:

> The test results . . . in Table 1 indicate that the best results were achieved in the polysilicon etch process of Example 1 using a mixed gas flow, while the best results were achieved in the silicon etch process of Example 2 and the polysilicon gate etch process of Example 3 using a predominately off-axis gas flow. . . . These test results demonstrate that the claimed plasma processing system, which allows the gas flow ratio between the on-axis and off-axis outlets to be changed for different steps of a multi-step process, can thus provide optimized process uniformity for each such step of a multi-step process,

Decl. 9.

Declarant Cooperberg further testifies:

> In contrast, because the Ni gas injector shown in Figures 1 and 3A-3C does not allow the gas flow ratio between the on-axis and off-axis outlets to be changed for different steps of a multi-step process, it cannot meet uniformity or customer standards for certain multi-step processes. For example, while the Ni injector can be designed to provide a mixed gas flow ratio that provides the results achieved in the process of Example 1, that same Ni gas injector would not be able to also provide optimized process results for the processes of Examples 2 and 3, for which predominately off-axis flow conditions provided the best process uniformity.

Decl. 10.

Declarant Cooperberg testifies:

> The Examples demonstrate that the particular flow ratio of the gas flows provided from the on-axis and off-axis gas outlets, i.e., predominately off-axis flow, predominately on-axis flow, or mixed on-axis and off-axis flow, that provides the most desirable results for a given step of a multi-step etch process . . . can be substantially different from the flow ratio of the gas flows that provides the most desirable plasma etch results for a different step of the multi-step process. For this reason, the Ni gas injector shown in Figure 1 and Figures 3A-3C is impractical

> for use in a plasma processing chamber for a multi-step etch process.

Decl. 11.

Appellants contend the evidence demonstrates "the existence of the problem of achieving, with a single injector, optimized process uniformity in a multi-step process that requires different gas flow ratios for different steps of the process, and that the claimed subject matter provides a solution to this problem" when compared with the injectors illustrated in Ni's Figures 1 and 3a-c. App. Br. 34-35, citing "Examples described at pages 19-21 of the present application" and Cooperberg Declaration ¶¶ 8-11. Appellants contend the results of the Specification Examples at pages 19-21 establish that the Ni "cannot provide adjustable, multi-zone gas flow via on-axis and off-axis gas outlets of the gas injector, and thus does not allow the gas flow ratio between the on-axis and off-axis outlets . . . ." App. Br. 34-35 (original emphasis deleted). Appellants contend "[t]he comparative test results . . . provide evidence that the Ni gas injector shown in Figures 1 and 3A-3C, which cannot change the gas flow ratio between its on-axis and off-axis outlets, cannot provide optimized process uniformity for process steps of a multi-step process," and thus even if Ni's injector can provide optimized results for the process of Example 1, that injector could not provide optimized results for the processes of Examples 2 and 3. App. Br. 35-37.

Appellants contend the results obtained with the claimed injector would not have been expected from the modification of Ni's injector by the teachings of the other applied art because "showerhead electrodes and gas injectors have very different structures and performance characteristics with

respect to the gas flow they provide." App. Br. 37. Appellants further contend the applied references do not suggest "the improved etch uniformity for multi-step etch processes . . . provided by the claimed gas injection system." App. Br. 37-38; Reply Br. 2-3.

We discussed above that one of ordinary skill in this art would have recognized from Ni's disclosure that control of the gas supply to the on-axis outlet of the injector can result in an injector useful in etching both aluminum (8 off-axis outlets) and polysilicon (1 on-axis outlet, 8 off-axis outlets) by providing the desired gas distribution with respect to the plasma and the substrate for each of the processes. *See above*, e.g., pp. 9-10 and 20-21. We also discussed above that the injector of Ni's Figures 1 and 3a-c has only off-axis outlets, Ni's disclosure is not limited to this injector, and that gas is supplied to the outlets of these injectors by a central bore. *See above*, e.g., pp. 8-11 and 16-17.

On this record, we find that the evidence of record as argued by Appellants does no more than show what one of ordinary skill in the art, armed with the knowledge in the art, would have reasonably determined from consideration of the combined teachings of Ni, Chang, Murugesh, Arami, Goodyear, and Balance, and thus the results reported by Declarant Cooperberg are not unexpected, as the Examiner points out. Ans. 19, *cf., e.g., In re Skoll*, 523 F.2d 1392, 1397 (CCPA 1975) (reference suggested the desirability of substituting reagent for that used in the process of another reference); *In re Gershon*, 372 F.2d 535, 537-39 (CCPA 1967) (references teach the superiority of using a reagent for a particular purpose). Indeed, the on- and off-axis gas distribution with the claimed injector in the different

silicon and polysilicon etch processes reported by Declarant Cooperberg is similar to gas distribution provided by the on- and off-axis gas outlets with respect to the plasma and the substrate disclosed by Ni for separate injectors used in the respective polysilicon and aluminum etch processes. We determine one of ordinary skill in this art would have reasonably expected that differences in on- and off-axis gas distribution can be obtained by modifying Ni's injector with separate gas passages or chambers for the on- and off-axis outlets, particularly in view of the teachings of Chang, Murugesh, Arami, Goodyear, and Balance. Indeed, these references disclose that more uniform results are obtained with greater control of the gas distribution through the use of separate gas passages to outlets in different areas of the injection. *See above* pp. 11-15.

Thus, while the combined teachings of the applied references do not expressly teach the results obtained in Specification Examples 1-3 as further reported by Declarant Cooperberg, we determine the same were obtained by routine optimization of the operation of a plasma processing system as a whole as taught by the references which is within the ordinary skill in the art, and not merely the injector. Thus, on this record, the results reported are not unexpected. Indeed, neither Appellants nor Declarant Cooperberg establish that the reported results would have been unexpected by one of ordinary skill in this art given the combined teachings of the applied references. *See, e.g., Pfizer, Inc. v. Apotex, Inc.*, 480 F.3d 1348, 1371 (Fed. Cir. 2007) ("[B]y definition, any superior property must be *unexpected* to be considered as evidence of non-obviousness." (citations omitted)); *In re*

Geisler, 116 F.3d 1465, 1470 (Fed. Cir. 1997); *In re Merck*, 800 F.2d 1091, 1099 (Fed. Cir. 1986); *In re Longi*, 759 F.2d 887, 897 (Fed. Cir. 1985); *In re Lindner*, 457 F.2d 506, 508 (CCPA 1972); *In re Klosak*, 455 F.2d 1077, 1080 (CCPA 1972); *In re D'Ancicco*, 439 F.2d 1244, 1248 (CCPA 1971).

Accordingly, based on our consideration of the totality of the record before us, we have weighed the evidence of obviousness found in the combined teachings of Ni, Chang, Murugesh, Arami, Goodyear, and Balance and as further combined with Powell, with Appellants' countervailing evidence of and argument for nonobviousness, and conclude, by a preponderance of the evidence and weight of argument, that the claimed invention encompassed by appealed claims 1 through 11, 13 through 15, and 39 through 61 would have been obvious as a matter of law under 35 U.S.C. § 103(a).

The Primary Examiner's decision is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED

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